

COMPARATIVE CLINICAL STUDY OF USING PIEZOELECTRIC ULTRASOUND SURGERY VERSUS CONVENTIONAL TECHNIQUE IN SINUS LIFTING PROCEDURE WITH SIMULTANEOUS IMPLANT INSERTION

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ABSTRACT

Introduction: Several methods have developed and are currently used for sinus lifting and augmentation. **Aim:** this study aimed to make a comparison between piezoelectric ultrasound surgery and conventional technique in sinus lifting procedure with simultaneous implant insertion. **Materials and Methods:** This case series consisted of twenty-four sinus elevations using the buccal lateral approach technique, the patients had defective upper posterior teeth for a long time with pneumatization of the sinus, they had bone height 5-7 mm which was insufficient for routine implant placement. **Result:** The results were evaluated by one-way analysis of variance. P values of less than 0.05 were considered to indicate a significant difference, bone density and implant stability are measure with CT for 6 months. **Conclusion:** While implant survival and bone gained are better with the ultrasound technique, perforations of the maxillary sinus membrane are more frequent in direct sinus lifts performed with the rotary technique (7%) than with ultrasound (1.7%).

INTRODUCTION

A rise in antral pneumatization occurs as a result of continual Loss of bone height and density, lack of stimulation, and bone remodeling⁽¹⁾. The gradual hollowing out of the alveolar process's apical aspect, which is mediated by osteoclasts, and an increase in positive intra-antral pressure are what lead to maxillary sinus pneumatization⁽²⁾. The remaining vertical bone height is reduced in this case, making normal implant placement challenging⁽³⁾. Maxillary sinus floor elevation has become a crucial pre-placement procedure in dental implant treatment planning to adapt, circumvent, and treat this local physiological as well as anatomical limitation⁽⁴⁾.

Different methods have developed to thicken the maxillary sinus floor. All such procedures aim to increase residual bone height as a treatment goal. Some of the procedures only require the minimal elevation of the maxillary sinus membrane and the Schneiderian membrane, while others also involve the implantation of allografts, autografts, bone morphogenetic proteins, and hydroxyapatite crystals⁽⁵⁾.

Several methods have been developed and are currently used for sinus lifting and augmentation⁽⁶⁾. The maxillary sinus floor is grafted using the Caldwell-Luc osteotomy method, which was historically the first major method used to provide enough bone for endosteal dental implants⁽⁷⁾.

By enabling simultaneous sinus floor elevation and implantation without necessitating a surgical sinus cavity opening, the summers osteotomy, used in the axial approach, was developed to simplify the sinus-lift procedure⁽⁸⁾.

The choice of procedure, whether a lateral approach with the Caldwell-Luc osteotomy or an axial approach with Summer's osteotomy, is largely determined by the alveolar ridges' residual bone height⁽⁷⁾. Currently, Summer's osteotomy technique can handle most straightforward cases, meaning there is no waiting period between grafting and implantation and less pain⁽⁷⁾.

However, when a severely resorbed maxilla or extensive implantation is required, the lateral approach offers better control of the surgical site⁽⁷⁾. The most common complication when elevating Schneider's membrane with the rotary approach is perforation of Schneider's membrane, which occurs in 10-35 % of all such surgeries and usually occurs during the osteotomy drilling phase while constructing the window for sinus access⁽⁹⁾.

The choice of procedure, whether a lateral approach with the Caldwell-Luc osteotomy or an axial approach with the summers osteotomy, is largely determined by the alveolar ridges' residual bone height. Currently, most simple cases can be treated with the summer's osteotomy technique, which implies less pain and no waiting time between grafting and implantation.

However, the lateral approach offers a better control of the surgical site, particularly in a severely resorbed maxilla or when extensive implantation is

needed making this approach with peizoultrasonic and conventional technique. Several approaches have been developed and are currently used for sinus lifting and augmentation⁽¹⁰⁾. The lateral approach using a Caldwell-Luc osteotomy is historically the first main technique where the maxillary sinus floor is grafted to provide a sufficient quantity of bone for the placement of endosteal dental implants.⁽¹¹⁾ The axial approach using the Summers osteotomy was developed to simplify the sinus-lift procedure using simultaneous sinus floor elevation and implantation without the surgical opening of the sinus cavity^(12,13).

The aim of this approach is to use the natural osteogenic properties of the Schneiderian membrane to gain the missing millimeters of bone around the tip of the implants.

This less invasive technique is an attempt to reduce the grafting volume to the strict minimum and generate only the required bone volume needed for the adequate osseointegration and anchorage of the implants⁽¹⁴⁾.

Implant stability in the residual bone height is a key issue, just as in the one-stage lateral sinus lift, and the use of implants with a micro threaded and/or tapered collar may be a relevant option to stabilize implants in a limited bone volume^(15,16,17).

The choice of the technique, a lateral approach using the Caldwell-Luc osteotomy or an axial approach using the Summers osteotomy, is mainly dependent on the residual bone height of the alveolar ridges.

Currently, most simple cases can be treated with the summers osteotomy technique, which implies less pain and no waiting time between grafting and implantation⁽¹⁴⁾.

However, the lateral approach offers a better control of the surgical site, particularly in a severely resorbed maxilla or when extensive implantation is needed^(18,19,20).

Recently, a third approach was developed based on the concept of guided bone regeneration. Several authors showed that a full sinus lift can be performed using the lateral approach with whole blood as the sole filling material ⁽²¹⁾.

This strategy requires the implants to be stabilized in the residual bone height (particularly by using implants with tapered and micro threaded collars) and to maintain the Schneiderian membrane pushed in the highest possible position using implant tips as tent pegs. This concept of bone regeneration leads to a very natural bone reconstruction around implants ⁽²²⁾.

However, this technique requires a very skilled surgeon because a perfect sinus membrane lifting without tears is necessary to maintain its osteogenic potential. Sinus elevation allows maxillary bone augmentation and thus facilitates implant rehabilitation in patients with severe posterior maxillary atrophy ⁽²²⁾.

In direct maxillary sinus lift a vestibular osteotomy is performed, a bone window is prepared, and access is gained to the maxillary sinus for elevation of the membrane. The bone perforation using an osteotomy drill of the conventional rotary technique, or using ultrasound tips ⁽²⁴⁾.

In elevation of Schneider's membrane with the rotary technique, the main complication is perforation of Schneider's membrane, which is observed in between 10-35% of all such operations ⁽²⁵⁾, which usually occurs in the osteotomy drilling phase while preparing the window for access to the sinus ⁽²⁶⁾.

Reducing the risk of perforating Schneider's membrane, vestibular osteotomy using ultrasound has been proposed, as this reduces the risk of soft tissue damage ⁽²⁷⁾ and membrane perforation to 7% ⁽²⁸⁾.

Some studies in the literature are preliminary descriptions of the technique ⁽²⁹⁾, while others present

isolated cases ⁽³⁰⁾, and others in turn report case series - no significant differences being observed between the two techniques ⁽³¹⁾.

The present retrospective study was designed to compare the performance of the rotary technique versus ultrasound in application to sinus lift, analyzing sinus membrane rupture in direct maxillary sinus lift with both instruments, Ultrasound (US) has been widely used in periodontics with good results for decontamination of root surfaces, mainly because of its efficiency for calculus removal ⁽³²⁾.

The idea of using an ultrasonic device in surgery was well demonstrated by Horton et al. ⁽³³⁾, showing good healing response compared to rotary bur.

Recently, a new type of ultrasonic device proposed by Vercellotti ⁽³⁴⁾ (developed by Mectron Medical Technology) known as piezosurgery broadened the possibilities of ultrasound use in clinical practice.

The aim of study using of piezoelectric ultrasound with lateral approach gives more benefit than conventional technique with implant insertion simultaneously after making sinus lift give more protection to sinus membrane.

MATERIALS AND METHODS

The present research was accepted from the approval of research ethics committee (REC) of the Faculty of Dentistry Suez Canal University with approved number (199/2019).

1- Patient selection:

Healthy patients in ASA* classes I and II participated in the study. This case series consisted of twenty-four sinus elevations using the buccal lateral approach technique. The patients had

5-7mm of crestal bone height, defected maxillary posterior teeth, and pneumatization of the maxillary sinus which was insufficient for routine implant placement.

2- Surgical protocol

The patients were divided into two equal groups.

Group I: Composed of 12 patients undergoing sinus lifting with piezoelectric ultrasound surgery for implant restoration.

Group II: Composed of 12 patients who will undergo sinus lifting with the conventional technique for implant restoration.

Inclusion criteria:

1. Missed upper premolar and molar related to sinus
2. Upper premolar and molar badly decayed related to sinus.
3. Limited bone over premolar and molar area
4. Edentulous area related to sinus.
5. Oro antral communication followed extraction
6. Remaining root related to sinus area
7. Periapical lesion with surrounding bone resorption
8. Chronic maxillary sinusitis

Exclusion criteria:

1. Patients suffering from hematological disorders (platelet function disorders anticoagulation therapy)
2. Renal or hepatic insufficiency
3. Pregnant or lactating women
4. Patient with bad oral hygiene
5. Diabetic patient
6. Patient with bone disease
7. Patients with immunologic diseases
8. Uncontrolled diabetes mellitus.
9. Patients that had chemotherapy or radiotherapy.
10. Other contraindicating systemic conditions were affecting bone healing were excluded.

Twenty-Four patients will be exposed by the same doctor exposed the buccal wall of the maxillary sinus, a crestal incision and full-thickness flap elevation were carried out under local anesthesia.

Group-I: Piezosurgery will be used to open lateral windows in the Mectron, Italy location. To prevent any perforation, Schneiderian membrane elevation will be carefully carried out.

Group-II: performed a direct maxillary sinus lift using the rotary technique. A handpiece carbide drill were used, along with ample irrigation with sterile physiological saline. Then implant was placed immediately in both groups.

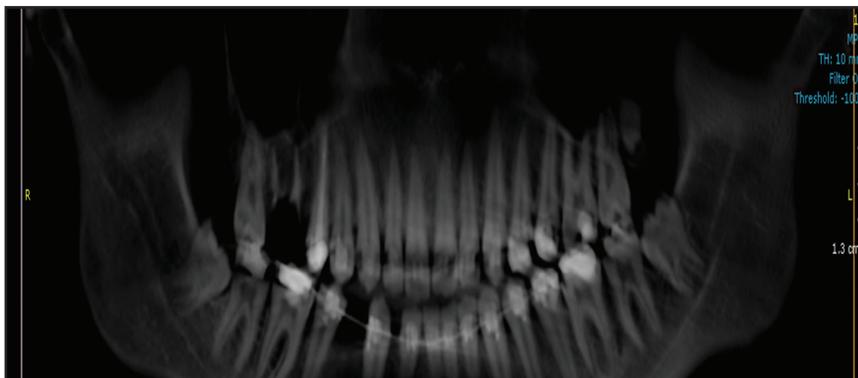


Fig. (1) Preoperative xray group I upper left six related to sinus make elevation using ultrasound peizosurgery.

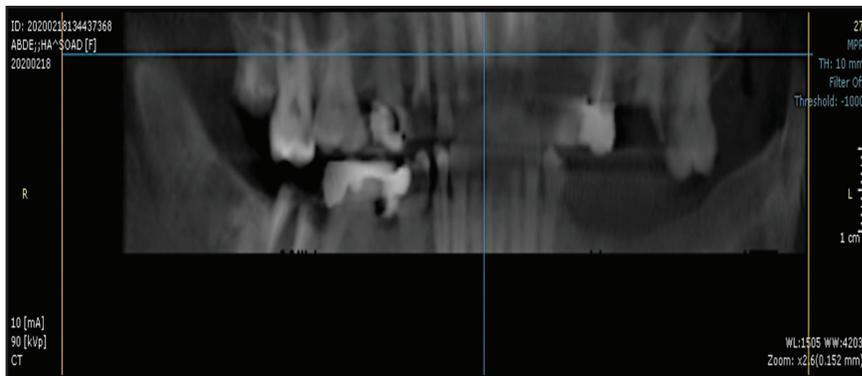


Fig. (2) Preoperative xray group 2 upper right six related to maxillary sinus making elevation using conventional technique.

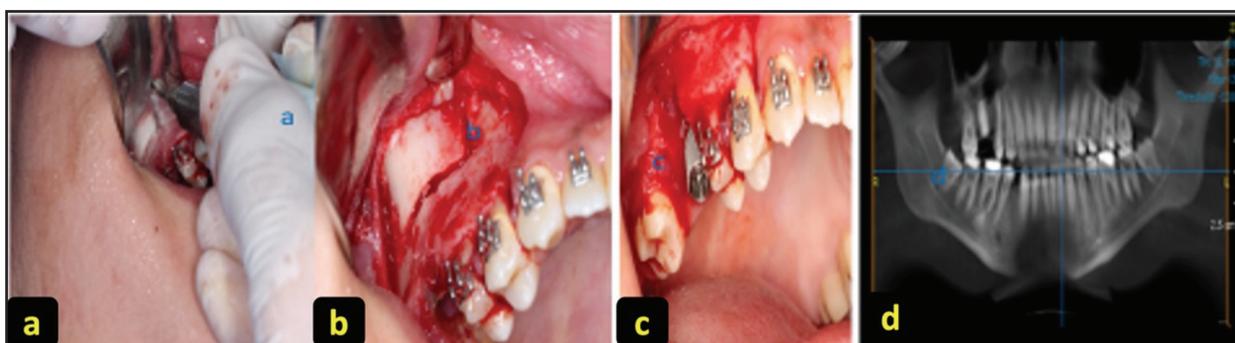


Fig. (3) Group 1 patients undergoing sinus lifting with piezoelectric ultrasound surgery for implant restoration (a) peizoultrasound surgery in making elevation of membrane, (b) making surgical lateral approach technique, (c) implant insertion after elevation of the membrane (d)- 3month x-ray after using peizoultrasound surgery in making elevation of membrane post operative x-ray for implant.

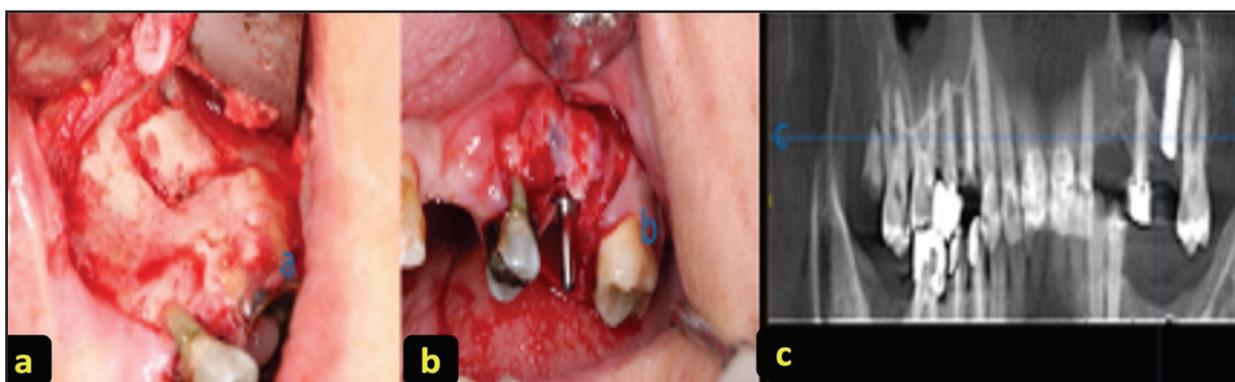


Fig. (4) Group:2 patients who will undergo sinus lifting with the conventional technique for implant restoration. (a) Conventional technique for sinus elevation with lateral approach. (b) Implant insertion after elevation of membrane with conventional technique. (c) X-ray after 3 month of implant insertion with sinus elevation using conventional technique.

Statistical analysis

The results were evaluated by one-way analysis of variance. P values of less than 0.05 were considered to indicate a significant difference.

RESULTS

Implant stability

According to the statistical methods, there was a statistically significant difference in the ISQ values between the study’s groups (Piezosurgery and Conventional groups) for the entire follow-up period of 6 and 9 months (P value= 0.04 & 0.003). The ISQ values were significantly increased with increasing the follow-up period (P value= <0.001) from Immediate operative time (61.50& 60.08) to 6 months (72.25& 68.75) and 9 months 78.17&75.50) in both groups respectively. Generally, the Piesosurgery group gave higher values than the conventional group for ISQ values all over the follow-up (Table 1).

Table (1) The mean ISQ values at different time points in group piezosurgery and Conventional

| | Piezosurgery group | Conventional group | Test value | P-value |
|--------------------|--------------------|--------------------|------------|---------|
| Immediately | 61.50±3.97c | 60.08±5.50c | 0.724 | 0.477 |
| 6 month | 72.25±3.72b | 68.75±4.79b | 2.362 | 0.04** |
| 9 month | 78.17±5.16a | 75.50±3.40a | 3.416 | 0.003** |
| F test | 45.67 | 33.20 | | |
| P value | <0.001** | <0.001** | | |

** , means a significant difference at p<0.05

Bone density

On radiographs, the average bone density in the piezosurgery group was determined immediately and 6 months and 9 months after the procedure, respectively was 48.5.83±(5.44), 54.1.08±(7.04), and 615.19±(4.30), where the conventional group recorded 445.50±(445.50), 496.50±(4.94), and 548.63± (8.20) in the same time structure. The outcomes revealed a statistically significant difference between the two groups, with improved bone quality at the site of piezosurgery (P ≤0.001), Table 2.

Table (2) Bone density (Mean ± SD bone density in mm in CBCT Scan piezosurgery and Conventional group)

| Postoperative intervals. | piezosurgery group | Conventional group | Test value | P-value |
|--------------------------|--------------------|--------------------|------------|---------|
| Immediately | 485.83±5.44c | 445.50±5.15c | 4.281 | <0.001* |
| 6 month | 541.08±7.04b | 496.50±4.94b | 5.018 | <0.001* |
| 9 month | 615.19±4.30a | 548.63±8.20a | 7.862 | <0.001* |
| F test | 12.69 | 34.89 | | |
| P value | <0.001* | <0.001* | | |

** means a significant difference at P<0.05

DISCUSSION

In alveolar ridges with insufficient height over time, the direct sinus lift procedure has evolved into a crucial surgical strategy for replacing posterior maxillary missing teeth over years (10). If the procedure is carried out carelessly, many issues can occur, including Schneiderian membrane perforation, discomfort, swelling, and improper wound healing (11). To avoid the aforementioned issues, the method of cutting the bony window and elevating the membrane are essential (12).

The piezo-surgery device is a safe choice for bone removal in delicate areas since it selectively cuts mineralized tissues while preserving soft tissues⁽³⁵⁾. Happe⁽³⁹⁾ stated that when the piezoelectric device is used properly, new bone production is faster than when revolving burs are employed.

The goal of this study was to assess the effectiveness of piezosurgery versus traditional sinus lift techniques. One of the most common consequences of the lateral sinus lift operation is perforation. This study's finding that there was no statistically significant difference in perforation between the two groups can be attributed to the fact that the same experienced oral surgeon performed each procedure. This agrees with Pjetursson, Rast⁽³⁷⁾ who examined the effects of lateral sinus elevation using both approaches on time spent performing surgery, perforation rate, and patient comfort. On the other hand, Barone et al.⁽⁴¹⁾ stated that when piezo-surgery is used, the perforation rate drops by 23%. While Malkinson and Irinakis⁽⁴²⁾ found in his retrospective investigation, they discovered a considerable variation in the rate of sinus membrane perforation, which he attributed to the fact that the procedures were conducted by different operators with varying levels of experience.

When the length of the surgery was measured from the beginning of the osteotomy to the full elevation of the sinus, group 2 was significantly quicker than Group 1. Many authors compared the times required to complete various surgical procedures using both approaches, and most of them discovered that piezosurgery takes longer⁽⁴⁰⁾. In contrast to Delilbasi and Gurler⁽⁴²⁾ found similar outcomes in their comparison. Similar to the present findings, Al-Moraissi et al.⁽⁴⁵⁾ showed that the piezo ultrasound technique took longer to perform in twenty-four studies were included in their meta-

analysis that examined both procedures of bone removal in lateral sinus augmentation.

Membrane perforations are the most reported intraoperative consequences of sinus augmentation⁽⁴³⁾. It has been claimed that 7-35 percent of sinus floor elevation procedures result in this condition⁽⁴⁴⁾.

The sinus membrane must be intact for the graft to be stable and for sinus infection to be avoided. It has been demonstrated that piezo surgery reduces the risk of perforating the sinus membrane⁽⁴⁵⁾. Testori et al.⁽⁴⁸⁾ reported in a total of 100 sinus lifts, seven membrane perforations were documented. All the perforations happened while utilizing hand devices to elevate the membrane, not during Piezo surgery.

Ultrasound has been linked to fewer membrane perforations, with a perforation rate of only 5%. Atieh et al.⁽⁴⁹⁾ compared traditional drills to a piezoelectric device for maxillary sinus floor elevation. They concluded that while Piezo surgery took longer for window osteotomy, the membrane perforation rate was lower than with the traditional approach.

The sinus lifts with the ultrasonic technique had a higher success rate than the rotary technique in this study. With piezo surgery, membrane perforations were also less common. In a similar study, Sivoletta et al.⁽⁴³⁾ showed neither method statistically significant differences in the rate of membrane perforation In 26 treated patients, 13 using the conventional rotational method and 13 using ultrasound.

In the current study, fewer perforations of about 3.2% of the Schneider's membrane were observed following direct maxillary sinus lifts. In contrast, Thor et al.⁽⁵⁰⁾ used the rotary approach to execute 27 direct maxillary sinus lift surgeries

in 20 patients. There were 11 perforations in the membrane (41 percent of the overall operations). Schwartz-Arad et al.⁽⁵¹⁾ used the same technique to achieve a comparable result. They found 36 perforations in 81 maxillary sinus lift treatments. They concluded that ripping the membrane influenced the occurrence of post-surgical problems, but not on the implant survival rate. Surprisingly, in this trial, all 24 implants were successfully integrated with no problems.

Ultrasound has been linked to fewer membrane perforations. Perforation repair can be difficult due to the extent of the perforation, and there is a chance of surgical failure⁽⁴⁹⁾. There is a universal consensus that surgeries with the Piezo-surgery device need a longer time. However, the duration for osteotomy and membrane elevation in the Piezo-surgery group was longer than in the traditional group⁽⁵¹⁾. In our investigation, the difference was not statistically significant. Because piezo-surgery uses micro-vibrations rather than macro vibrations and sounds, it produces less vibration and noise than traditional rotary techniques⁽⁵²⁾.

CONCLUSIONS

- This study found that perforations of the sinus membrane are more common in direct sinus lifts performed with the rotary technique than with ultrasound.
- Piezo-surgery generates less postoperative pain and swelling, while ultrasound enables precise bone removal with a reduced risk of injury or perforation.
- CBCT can accurately assess bone development before sinus elevation and implant placement, making it easier to select the appropriate implant size.

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